

EDINBURGH UNIVERSITY.

THESIS FOR DEGREE OF

DOCTOR OF MEDICINE. 1921.

----- S U B J E C T -----

AN INVESTIGATION INTO THE ETIOLOGY OF DEFECTIVE
VISION CAUSED BY ERRORS OF REFRACTION.

- by -

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AN INVESTIGATION INTO THE ETIOLOGY OF DEFECTIVE
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The publication in Germany, in the year 1885, of Cohn's "Hygiene of the Eye" brought into prominence the necessity of testing the vision of school children.

Since that date and principally owing to the figures which Cohn showed, and the conclusions he based upon them, the subject has received a large amount of attention in all countries. It was not, however, until the year 1908, when a system of Medical Inspection of School Children was first established in this country, that any attempt was made in England to obtain information on a large scale on this important subject. Before this date, information could only be obtained from the results recorded in other countries, notably Germany and the United States of America. These results, whilst no doubt giving a reliable index of the percentage of visual defect found amongst the school children of the country from which the reports emanated, could not with equal scientific accuracy be so applied to the school children of the British Isles. For instance, the percentage of Myopia found amongst German children is much higher than is found in this country.

Almost the only source of information previous to 1908 with regard to this subject in

England was derived from reports on the examination of Industrial Schools and Institutions of a similar nature. Such information, in view of the comparatively small numbers involved, was quite unreliable when applied to the children of the country as a whole.

The annual reports of School Medical Officers and the Chief Medical Officer of the Board of Education have however yielded much information on the subject and stimulated interest in the matter.

Now, statistics are available showing the numbers and percentages of children exhibiting defective vision. Many books and articles have been written on the subject and much work of a research nature has been undertaken.

Some idea of the amount of defective vision existing amongst school children may now be given by quoting extracts from books and Annual reports.

Kerr, writing in "Newsholme's School Hygiene" states, that the percentage of defective vision is higher in girls than in boys, and younger children exhibit a higher percentage than those older. He also gives figures of tests carried out at Bradford. In the first series of tests, 39,118 children were examined, and the percentage falling short of normal vision was progressively less from 43 per cent at age 7 to 9 per cent at age 14. In the second series of tests, 7,755 girls and 7,787 boys were examined. The boys showed vision less than

normal in 44 per cent of cases at the age of 7, and a gradually lessening percentage up to the age of 13 when the percentage was 16.5. In girls, at the age of 7, 50 per cent had visual acuity less than normal and at age 14, 18 per cent only were deficient. He further states that 10 per cent have vision as bad as 6/18 and that this is a constant throughout school life. Visual acuity of 6/36 or worse is in increasing proportion from 1.5 per cent at age 7 to 3.5 per cent at age 14.

The Annual Report of the Medical Superintendent of Schools, Lancashire for 1910 shows that 9,926 boys and 10,037 girls at the age of twelve years were subjected to a test of vision. Of the boys 86 per cent had normal vision and 14 per cent were less than normal. The girls showed 83.5 per cent less than normal.

These tests were carried on through the years 1911, 1912, 1913 and 1914, and in his Annual Report for the latter year, the Medical Superintendent gives a further analysis of the vision tests for children aged 12, 13 and 14. Altogether 43,994 boys and 44,630 girls were tested. The boys showed 84.1 per cent of good vision and the girls 80.6 per cent. (Good vision was arbitrarily fixed as those who saw 6/6 or 6/9 with each eye.) The respective percentages of defective vision were 15.9 in the boys and 19.4 in the girls. At the same ages and with the same figures as above,

the percentage of those who saw 6/6 with each eye was 73.4 in the case of the boys and 67.1 of the girls; so that 26.6 per cent of the boys and 32.9 per cent of the girls had visual acuity less than normal.

Cohn in his "Hygiene of the Eye" states that he examined the eyes of 1,486 children attending rural schools and of 8,574 children attending urban schools - a total of 10,060 - and found that 83 per cent were emmetropic. 13 per cent showed refractive errors, and 4 per cent suffered from other diseases of the eye.

Bishop Harman in his "The Eyes of our Children", states that in an examination of 341 boys and 328 girls, the latter had 26 per cent of faulty vision and the former 18 per cent.

Dr. S. D. Risley writing in Norris & Oliver "System of Diseases of the Eye" on School Hygiene gives some statistics from America. He states that in school statistics the following relation was shown:-

Emmetropia	11.19%
Hypermetropia & Hypermetropic) Astigmatism)	74.04 %
Myopia and Myopic Astigmatism	13.7 %
Mixed Astigmatism	12.09 %

The quotations given above show the conditions which exist amongst the school children in England, Germany and the United States of

America.

In each country the percentage of visual defect is sufficiently large to warrant strong measures being taken to combat the serious effects which such defects have on the educational efficiency and the industrial life of the country.

In Lancashire the well being of the people is dependent on the cotton industry. A large proportion of the children attending Lancashire Schools subsequently enter cotton factories. Cotton work demands efficient eyesight and workers with defective sight prove but poor workmen where the defect is uncorrected.

It was with such facts in view that this investigation was undertaken. It was an attempt to obtain some information of the factors governing and affecting defective vision in school children.

The enquiry was conducted partly during the course of routine medical inspection of schools and partly by special visits to the schools for the purpose.

The first part of the investigation was started during the years 1913 and 1914, but unfortunately this part was interfered by the advent of the European War, with the result that the information collected was incomplete. This part was especially devoted to the influence of heredity on the causation of defective vision, and as at the termination of the War the children

examined had left school in the interim, it was found impossible to complete the figures. The result is that only those numbers which were more or less completed before the interruption are given.

Since the end of the War, the investigation has been continued but with different schools and different children. In these latter parts of the enquiry other factors have been considered which might have an influence on the etiology of visual defect.

At this point it must be clearly stated that visual defects caused by Mental Disease or Eye Disease, other than errors of refraction, are not included in this enquiry,

The investigation only comprises defective vision caused by hypermetropic, myopic and astigmatic defects.

THE COMPILATION OF THE INVESTIGATION.

For the sake of compactness, the defects have been collected into three groups:- Hypermetropic; Myopic; and Mixed Astigmatism.

It was also felt that all the elements of each group were probably influenced in the same way by each factor considered.

The Hypermetropic group comprises, Hypermetropia, Hypermetropic Astigmatism and Compound Hypermetropic Astigmatism.

The Myopic group includes, Myopia,

Myopic Astigmatism and Compound Myopic Astigmatism.

The Mixed Astigmatism group consists of Mixed Astigmatism and a few cases of Anisometropia.

The visual defects are thus divided into those caused by:-

- (1) The short eye.
- (2) The long eye, and
- (3) The irregular eye.

It has already been stated above that the investigation does not show a continuity of children and schools insomuch as it was interrupted by the War. In consequence several sets or series of figures are dealt with, and it has been found most convenient to consider each group of defects under the heading of the factor concerned rather than to consider each group of defects separately.

This makes greater ease of annotation, requires fewer tables of results, and gives greater clearness in comparison between the respective groups of defects. Thus under the factor "Heredity" is considered the respective groups Hypermetropia, Myopia and Mixed Astigmatism.

After all the factors have been considered and the results given of the influence each factor has borne on the various groups of defects; a short resumé with conclusions based on the results found is annotated for each group of defects separately.

A list is given below of the factors investigated as being likely to have some effect on the etiology of defective sight.

The factors are as follows:-

- (a). The influence of Heredity.
- (b). The Age influence.
- (c). The influence of Sex.
- (d). The influence of the Lighting of Schools.
- (e). The influence of Environment.
- (f). The influence of Consanguinity.
- (g). The Racial influence.

Before taking the factors seriatim, a short account is given of the general methods of procedure pursued in testing the vision of the school children and the method of diagnosing the actual errors of refraction. The more particular methods are described under their respective sections.

METHODS OF PROCEDURE.

Each child, who was being examined, was tested first of all by Snellen's Test Type at the required distance of 6 metres. A site giving good illumination was chosen for the card.

Each eye of every child was tested separately and the results noted. All children who did not see 6/6 with each eye were marked down for further examination. Besides these, all children who read 6/6 with each eye but who exhibited signs of Eye Strain, Conjunctivitis or Blepharitis were also put on the list for further examination. By this means, all or practically all of those children who had latent defects as well as those who had manifest defects were subjected to

further examination.

The further examination consisted of examining the children by means of the Ophthalmoscope for signs of Fundal or other diseases and then subjecting them to a retinoscopic test.

The examination by means of the ophthalmoscope was performed in a room which was specially darkened for the purpose. So far as possible a room was chosen which was over twelve feet in length.

The illuminant used was an ordinary wax candle in order that too powerful a light should not be given and thus cause pupillary contraction.

In view of the large number of children examined it was not found possible to use a mydriatic as a routine.

The large number examined was not the only difficulty encountered in the use of a mydriatic, but the fact that the parents' consent had first to be obtained and as many of the children's homes were long distances from the school this was extremely difficult to obtain.

The method of performing the retinoscopic examination with an undilated pupil was as follows:- The child was instructed to look at some object on the wall at a level just above the examiner's head, the wall most distant from the candle being chosen for this purpose. By this means a very considerable degree of relaxation of accommodation was achieved. The results thus

found were in many cases afterwards confirmed by the use of mydriatics and in others by testing the eyesight with trial lenses. It was found that a quite reasonable degree of accuracy was attained by this method.

As a further precaution all errors of refraction of less than one dioptré of myopia or hypermetropia were rejected and only those children exhibiting one dioptré or more of error were annotated.

The somewhat feeble illuminant was a great help in not causing pupillary contraction by too strong a light.

Children under the age of six were not examined in connection with this investigation as they are quite unreliable in Snellen's test and are very difficult to examine by means of a retinoscope without mydriasis. The errors of refraction found were classified into the three groups already described above.

The ages of the children varied from six to thirteen and both boys and girls are included except where it is otherwise stated.

The first factor that was investigated was:-

(a). THE INFLUENCE OF HEREDITY.

Oculists in all countries have enquired into and written on this side of the etiology of visual defect. The majority of them agree that in

the case of Myopia, if heredity is not the actual cause, at least it is a very strong predisposing one. It has been the opinion of some of them that Myopia is always hereditary.

In the case of Hypermetropia, the opinions given are much more guarded, for although most text books state that Hypermetropia is practically always congenital only a minority of them express an opinion as to its hereditary origin.

Mixed Astigmatism is generally dismissed in a few sentences and no description is, as a rule, given of its etiology.

Quotations from certain authors are given under the respective groups of defects considered.

During the course of the investigation into the hereditary factor some 3,000 children in all were examined. Of these 867 were subjected to further Ophthalmoscopic and Retinoscopic examination. Many of these 867 were found to be emmetropic and others exhibited an error of less than one diopetre and were accordingly discarded for the purpose of this enquiry.

A short description must now be given of the methods used for obtaining the information as to the hereditary influence.

Out of 867 children subjected to a retinoscopic examination and after the emmetropic, and children with less than one diopetre of error were eliminated a certain number remained who were suitable subjects for the purpose of further particulars

and enquiries. (It might be stated here that children wearing glasses already had exactly the same routine examination as the others and are included in the numbers given).

Of the numbers remaining after the eliminations, one child out of each family, where more than one had been examined, was chosen. The further enquiries were now devoted to the family history, of the child with regard to the question of the defective sight.

The number of families thus enquired into was 432. This number must not, however, be taken as an index of the number of children exhibiting refractive errors of over one dioptre but is simply the number of those into whose family history it was possible to enquire. There were many others whose family history would have been enquired into, had this part of the investigation not been abruptly concluded by the outbreak of War.

The acquirement of information on the questions of the hereditary influence and of the family history generally, presented difficulties of great magnitude when undertaken during the course of medical inspection of schools.

The schools in which the examinations were performed were scattered over a large area of Lancashire and included rural as well as urban schools. This greatly increased the difficulty of obtaining the information desired as it was necessary, in order to get reliable information, to

see the parents of the children.

In Lancashire it is the custom for both parents to go out to work, and this also caused increased difficulty of getting in touch with them.

In this part of the investigation; the help of the School Nurses was enlisted and they were supplied with the details of each case and a list of the information desired.

It was not found possible to test the vision of the parents of the children as this is outside the work and sphere of a School Medical Officer. It was realized that this was the only manner in which scientific accuracy could be obtained but the difficulties proved insuperable.

The ideal being unattainable, the method of obtaining the evidence of defective sight or otherwise of the Parents was as follows:- information was obtained from each parent as to whether he or she had ever worn glasses and also whether these had been worn for near or distant vision. If glasses were only worn for near vision and the person concerned was over forty years of age such was not accepted as showing evidence of defective sight. Presbyopia was thus excluded.

Where glasses were not worn it was attempted to obtain evidence from the parents concerned as to the state of their vision. This was obtained by questions as to whether they had good vision or not. This latter evidence was of

doubtful value as it was found that people of limited education were seldom conscious of visual defect where it existed. Where the parents admitted visual defect it was found to be generally reliable information. The evidence, therefore, is not conclusive in the case of those children whose parents gave no history of defective sight as probably a large number of them were affected without their knowledge. A certain number of parents also gave wrong information in attempting to discredit the evidence that their child required glasses.

Where the evidence was positive it could be relied upon, as working people are extremely averse to the wearing of glasses unless the need is very great.

Along with the history of defective sight amongst the parents, information was obtained of the evidence of defective sight or otherwise of brothers or sisters of each child enumerated. This will be afterwards called the "Familial Influence".

It has already been mentioned above that in certain cases more than one member of a family was examined at school. The "Familial Influence" whilst not strictly coming under the influence of Heredity is considered here as it is probably closely related to the question of heredity.

Each group of defects will now be considered separately in relation to the governing factor - Heredity -

The first to be considered is hypermetropia

and its allied astigmatism grouped under the term:-

Hypermetropia.

It has been stated above that the opinions of standard authorities are somewhat at variance on the question as to the part that heredity plays in the etiology of hypermetropia.

Some of these opinions are now given.

Swanzy & Wernher in their manual "Diseases of the Eye" express the opinion that children are hypermetropic at birth but become less so, as the eye develops. They also state that the eyes of uncivilised nations are hypermetropic.

Bishop Harman in "The Eyes of our Children" does not discuss at all the hereditary influence on this condition but states it ~~is~~ often congenital.

Cohn in "The Hygiene of the Eye" states that hypermetropia is almost always congenital and often hereditary. He gives however, no figures to support this view.

Risley in "Norris & Olivers", "System of Diseases of the Eye" expresses no opinion as to the influence of heredity on pure hypermetropia but is of the opinion that astigmatism is inherited.

These quotations are sufficient to show that opinion is divided on this subject.

Before proceeding to discuss the results of the enquiry, a short account of the percentage of visual defect due to hypermetropia is annotated. In this country the percentage of defect due to hyper-

metropia is usually considerably greater than that due to Myopia, the reverse of that found by Cohn in Germany. The relative percentage as found by Dr. Jones in an investigation by him in Lancashire schools was of hypermetropia 13.6 per cent in boys and 13.1 in girls as opposed to 2.3 per cent and 4.0 per cent respectively in the case of myopia.

The results of the present investigation are now given below with an explanation of the method of tabulation.

Of the 432 cases inquired into 282 were found to be affected by hypermetropia and its allied astigmatism. This gives a percentage of 68.3. The percentage is purely an arbitrary one and not actual. It is only a percentage of the cases fully investigated.

A table is given below of these 282 cases, analysing the results found in the enquiry into the family histories. An explanation must first be given of the headings of the table in order to give greater clearness.

Where the father of the child gave evidence of defective sight the case is entered under the heading "Father affected". Similarly for the mother.

Where both father and mother were affected the case is entered under "Mother and father affected"

Columns are also given of the cases where the father and other children in the family are affected, and similarly also for where the mother and other children of the family are affected, and where

both parents and other children are affected.

The next column gives those cases where the parents gave no history of defective sight but where brothers or sisters were affected.

The last column gives the cases where no history was obtained of visual defect in any other members of the family.

The numbers of cases are given in each column and below the numbers, the percentages.

T A B L E .

	1	2	3	4	5	6	7	8
	Father affected	Mother affected	Mother and father afftd.	Father and other chld.	Mother and other chld.	Mother and father and other child	Other Chld. afftd	None in Family
No.	19	50	11	11	27	6	84	118
%.	6.7	17.7	3.9	3.9	9.5	2.1	29.7	41.8

The figures in columns 4, 5, and 6, are part of and included in columns 1, 2, and 3, consequently it will be noticed that the numbers total more than 282 and the per centage to more than 100.

Columns 1, 2, and 3 are entirely separate cases and if they are added together it will be found that 80 cases out of 282 or 28.3 per cent give a history of hereditary influence.

This figure can only be considered as a minimum one for the reasons stated above in the methods of obtaining information. If it had been possible to examine the eyesight of all the parents a very much higher percentage

of defective sight amongst them would undoubtedly have been found.

It must again be pointed out that the cause of the parents defective sight is not separated in this inquiry into the groups of refraction errors as in the case in that of the children, so that it is possible for a child affected by hypermetropia to have a myopic parent. It was not found possible to find out definitely the parents errors for the reasons stated earlier in this paper. Cases of defective vision due to accident, corneal opacities, cataract and fundal disease were excluded so far as possible.

Had this part of the enquiry not been so summarily interrupted, an attempt would have been made to get some idea of the underlying cause of the parents visual defect.

If columns 1, 2, 3, and 7 be added together some idea may be obtained of the familial predisposition to this defect. The actual numbers are 164 and the percentage of the total suffering from hypermetropia, is 58. In connection with this predisposition it was found comparatively frequently during the investigation that all children in the family were not affected, even where one or other or both parents were affected. Children examined in such families were found to be emmetropic whilst others were hypermetropic. In some instances one child was found to be hypermetropic whilst a brother or sister was found to be myopic or to have mixed

astigmatism.

It is interesting to note that the cases where the mother alone was affected exceeded those where the father alone was affected; a percentage of 17.7 as opposed to 6.7 per cent. This also was found to be true of the columns where mother and other children affected are noted and father and other children affected are noted. The respective percentages are 9.5 and 3.9.

From these figures, it appears that the maternal hereditary influence is greater than the paternal. It is not quite clear why this is so. It may be accounted for by the greater proportion of defective sight found amongst the female sex and thus giving a larger number of mothers wearing glasses than fathers. It may also be accounted for by the fact that men as a rule object more strenuously to the wearing of glasses than women do. In this connection it has been found during the course of medical inspection of schools much easier to persuade parents to have treatment for their daughters eyes than for their sons.

Thus the greater maternal influence in heredity may be an accidental one in these figures or it may be actual. No more definite conclusion can be drawn without fuller details.

The number of cases found where both parents were effected is small with a percentage of 3.9 and still smaller where both parents and other members of the family are affected 2.1 per cent. The smallness

of these percentages may be accounted for by natural selection of mates and also by Nature's efforts to strike an average, thus preventing both parents being affected by defective sight in the majority of cases.

The largest number of cases showed no evidence of defective sight amongst the parents. This number can be obtained by adding together columns 7 and 8 and is 202 and the percentage is 71.6. Column 8 gives the cases where no familial predisposition could be found (41.8 per cent). It has already been stated that both these percentages ought undoubtedly to be lower.

During the course of the investigation, one boy the son of a head teacher of a school was found to be suffering from Compound Hypermetropic Astigmatism and the teacher himself was so affected. The teacher volunteered the information that his father was also similarly affected. This gives a hereditary descent of the error through three generations in the male line.

The results as a whole do not give sufficient evidence, partly due to the paucity of numbers and partly to the incompleteness of the information obtained, to case a firm opinion as to the exact influence heredity has on the etiology of Hypermetropia.

The percentage (28.3) where the evidence obtained showed parental visual defect is undoubtedly much too low. It is considered that 40 to 50 per cent

would more probably represent somewhere about the true percentage.

It cannot be claimed from the results of this enquiry that hypermetropia is always hereditary in origin. The results do show, however, that heredity does play quite a considerable part in the etiology of this defect and that an abnormal eyeball in a parent has a tendency to be transmitted to the children.

It can also be concluded that certain families show a predisposition to develop hypermetropic defects and in this enquiry the predisposition was found to affect 58 per cent of the families examined. It can also be concluded that on the whole the maternal hereditary influence is the stronger one.

The influence of Heredity on Myopic conditions has now to be considered.

MYOPIA.

Since Cohn first published his investigations into this condition, many investigators have followed in his footsteps in all countries.

The results published have been numerous and frequently contradictory.

Oculists have divided themselves into two opposing camps on the vexed question of the influence of heredity, and this variance in opinion persists to the present day in spite of the numerous text books and articles on the subject.

In the British Medical Journal in the autumn

of 1919 articles appeared from both camps and the subsequent discussion which arose only served to accentuate the doubt which shrouds this question.

Cohn gives figures which show that in an enquiry which he directed into this question, out of 1,004 myopic scholars only 2.7 per cent had a myopic father or mother.

Erismann on the contrary found that myopia was inherited in 30 per cent of all cases of myopia examined.

Donders states "My experience shows that Myopia is almost always inherited and when inherited exists in the child at least in the form of a predisposing tendency."

Cohn's final opinion was that the question of heredity influence in myopia is not yet decided; that the transmission of the tendency to myopia is at least probable but that in many cases without any hereditary predisposition, myopia is developed by other causes.

Risley in Norris and Oliver's "System of Diseases of the Eye" states that it is rare to find myopic children in families where both parents have normal eyes. He is of the opinion that congenital anomalies in the form of the eyeball are hereditary rather than the myopia itself or any tendency to myopia.

Bishop Harman in the "Eyes of our Children" states that some 3 per cent of children are myopic, and gives figures which show that 17 per cent of 300

children found myopic gave a definite family history of myopia. He considers that there may be an inherited predisposition to the stretching of the coats of the eyes.

Swanzy & Wernher in their text book "Diseases of the Eye" say "That myopia is rarely congenital. It is almost wholly a result of civilisation and its development and increase are due to the use of the eye for near work.

Heredity also plays a part which, however, is not quite clear, but it would seem that some anatomical or constitutional predisposition must be transmitted to the offspring".

Sufficient opinions have been given to show the variance in views which exists on the question of the influence of heredity on the etiology of myopia.

The results of this investigation are given in a table below. Out of the 432 children investigated on this question, 116 were found to be suffering from Myopia or Myopic Astigmatism (26.8 per cent). This percentage as in the previous table is an arbitrary one and for the same reason.

In the table the same columns are used as in the previous table of Hypermetropic cases.

	1	2	3	4	5	6	7	8
	Father affected.	Mother affected.	Mother & Father affected.	Father and other chld.	Mother and other chld.	Mother & Father & other <i>chld.</i>	Other Chd.	None in family.
No.	11	26	6	3	10	4	23	50
%	9.4	22.6	5.1	2.5	8.6	3.4	19.8	43.1

The same remarks about the grouping of the figures in the columns and also the percentage apply here as in the previous table, e.g. the numbers come to more than 116 and the percentage to over 100.

It is seen that columns 1, 2, and 3, all give higher percentages in this table than they did in the case of hypermetropia whilst the other columns with the exception of column 6 give lower percentages.

If the figures in columns 1, 2, and 3, be added together it is found that the figures and percentage are respectively 43 and 36.9. These columns give the percentage and number of cases where positive evidence was found of errors of refraction in one or other or both parents. In other words they give a measure of the hereditary influence. Actually then 36.9 per cent of the cases investigated gave a history of defective sight in the parents.

This figure compares with the 30 per cent found by Erismann in his cases but his figures refer only to cases where the parents were found myopic whereas the figures in this investigation refer only to errors of refraction which are not differentiated. Again it must be stated that this percentage (36.9) is too low and undoubtedly would have been much higher if fuller information could have been obtained. It is a minimum percentage.

It is a considerably higher percentage than was found in the case of hypermetropia (28.3).

It must not be concluded from this percentage that 36.9 per cent of myopic parents, as in Erismann's

cases, pass on their defect to their children, but that 36.9 per cent of myopic children give a history of parental visual defect.

In these results it is also found that the maternal hereditary influence is stronger and more liable to be transmitted than the paternal. It was similarly so in the case of hypermetropia.

It is also seen that more cases of Myopia are found amongst the children where both parents have defective sight, than Hypermetropia.

Where the mother or father is affected along with other children of the family the percentage is less in the case of myopic children than in the case of hypermetropic, but where both parents are affected along with other children of the family the percentage is greater in the case of myopia. Where other children in the family are affected (Column 7) the percentage is found to be less than in the case of hypermetropia 19.8 as opposed to 29.7.

The familial predisposition can be obtained by adding up columns 1, 2, 3, and 7, and the percentage is found to be 56.7. This percentage is very similar to that found in the case of hypermetropia.

When examining the children it was found in certain cases that where a child was myopic its brothers or sisters were also unusually myopic but in a small number of cases the brothers or sisters were hypermetropic or had mixed astigmatism and others were emmetropic.

During the course of the investigation, one

family consisting of father, mother, and six children were all found to be myopic. The majority of them suffered from high and progressive myopia. The youngest child aged five, had seven dioptre of myopia in each eye. All observers do, however, agree on this subject that cases of high or progressive myopia are always hereditary but it is rather unusual to find so many myopic subjects in one family.

Families where two or more cases of myopia were found were common.

It would be difficult on the figures given in the table to say that myopia is always hereditary, for the number examined is too small and the details of family history too incomplete to make such a sweeping conclusion. It can however be said from these figures, that myopic children give a parental history of visual defect in about 40 per cent of cases.

It can be deduced with even more scientific accuracy that the presence of an error of refraction in a parent is a predisposing influence to the development of Myopia in the children in about 40 per cent of cases.

The opinion is usually expressed in text books that babies are practically always hypermetropic. If this view be correct, and it is widely accepted, the predisposing influence just discussed cannot be said to produce Myopia in very young children but rather some inherent weakness in the eyes which later on allows them to become myopic. This weakness may quite well be some lack of strength in the coats of the eyeball. It can be compared to somewhat

analogous conditions found in the case of Hernia and Varicose veins.

MIXED ASTIGMATISM.

This is the least commonly found of all errors of refraction in children and, in consequence, manuals on School Hygiene either do not mention it or dismiss it in a very few sentences. No statistics are given on the subject nor any opinion on its etiology.

Risley in Norris and Oliver's text book states that "Mixed Astigmatism is more common than usually suspected. Cases examined without the aid of a mydriatic and thought to be Myopic Astigmatism were found under atropine to be cases of Mixed Astigmatism". He is of the opinion that Mixed Astigmatism is a definite turnstile on the road from Hypermetropia to Myopia.

The effects of Mixed Astigmatism are more determined by the myopic meridian than by the hypermetropic one so that it might almost be described as a Myopic affection.

In the table given below the same division of figures and the same columns are used as in the previous tables. Naturally the figures are very much lower than in the previous tables.

The total number of cases of mixed astigmatism found was 34 out of a total of 432 cases investigated.

T A B L E.

	1	2	3	4	5	6	7	8
	Father affected	Mother affected	Mother and Father affected	Father and other chld.	Mother and other chld.	Father and Mother & other child	Other Chld. only.	None in family
No.	3	7	3	1	1	1	4	17
%.	8.8	20.5	8.8	2.9	2.9	2.9	11.7	50.0

When columns 1, 2, and 3, are added together, the percentage of children whose parents gave evidence of defective sight is found to be 38.2. This percentage is slightly higher than was found in the case of Myopia. It is also significant that the separate percentages in Columns 1, 2, and 3, correspond closely to those found in the results found in Myopia (9.4 22.4 and 5.1) Column 3 gives somewhat higher percentages than in the case of Myopia. All three columns are higher than in the case of Hypermetropia.

The familial influence or predisposition is obtained by adding columns 1, 2, 3, and 7, and gives a percentage of 49.8 and this is lower than was found in both Hypermetropia and Myopia.

Where however the numbers are so small, a very considerable error is liable to develop in the percentages; and scientifically little dependence can be placed upon them.

The percentage, where no evidence of defective sight could be obtained in the family, is rather higher than in the previous tables, namely 50.

As Mixed Astigmatism can hardly be recognised as a distinct defect by itself but rather as a mixture of myopia and hypermetropia, it would be difficult

definitely to decide the influence that Heredity plays.

Bishop Harman and Risley both consider it to be a transitional stage between hypermetropia and myopia and from the very nature of the defect this would appear to be logical. In consequence figures obtained in this defect can only be taken as in support of figures on hypermetropia and myopia.

In this investigation the results obtained do correspond very largely to those obtained in the cases of hypermetropia and myopia. This applies to the hereditary influence and the familial predisposition.

When examining the children, instances were found of more than one case of mixed astigmatism in a family. With the previous remarks about the percentage error borne in mind, it still must be concluded in this condition as in the others that the presence of defective sight in the parents has undoubtedly some effect on the production of mixed astigmatism in the children. The exact percentage of cases in which this occurs cannot easily be deduced from the small number of cases examined. It may be higher or lower than the figure (38.2) found in this investigation.

This concluded the part of the enquiry which was devoted to obtaining evidence on the influence of heredity on visual defect.

For the continuation of the enquiry into the influence of other factors, which will be taken in due order, entirely fresh series of figures are

used.

The next factor investigated and now to be considered was:-

(b) THE INFLUENCE OF AGE.

This part of the investigation was devoted to obtaining evidence of the amount of visual defect found at different age periods of school life, and to the effect which growth in years has upon the incidence of cases of myopia, hypermetropia, and mixed astigmatism.

Methods of Procedure.

In this part of the enquiry entirely different methods of obtaining figures were employed. Whole schools were tested and the results tabulated into ages and series. (The sex influence will be dealt with in the next section of the enquiry).

The same routine methods were pursued in examining the children's eyesight as previously annotated.

The children were tested in definite age groups which were adopted as follows:-

<u>Group 1.</u>	ages 7 and 8
<u>Group 2.</u>	ages 9 and 10
<u>Group 3.</u>	ages 11, 12, and 13.

In all 1,000 children were examined, 485 boys and 515 girls, but in the results given girls and boys are combined in the different age groups.

Below is given the table analysing the results found. The columns of the table are self explanatory.

	Hyper Metro- pia.	Myopia.	Mixed Astig- matism.	Total No. & percentage of defect.
Age (No. Group { 1 { %.	38 14.9	7 2.7	2 0.7	254 18.3
Age (No. Group { 2 { %.	53 15.6	8 2.3	2 0.5	339 18.4
Age (No. Group { 3 { %.	48 11.7	20 4.9	5 1.2	407 17.8

The numbers examined are rather too small to give reliable statistics and percentages but they serve to give some indication of the influence that age has upon the various errors of refraction amongst school children.

In the case of the Hypermetropic group of defects it is seen that the percentage is slightly greater in the second age group (ages 9 and 10) than in the first group but that in group three (ages 11 to 13) there is quite a considerable drop in the percentage found.

This agrees with the commonly accepted view that errors of refraction due to hypermetropic defects become less as children grow older.

Swanzy's opinion is that "Children are hypermetropic at birth but with the growth of the body the eye develops and becomes less hypermetropic".

Other oculists state that many of the cases of hypermetropia found amongst very young children either

become Emmetropic or due to the influence of school work become Myopic. They explain the presence of hypermetropia in older people as being due to an arrest of development in the eye at a stage before it has become emmetropic.

With such small numbers examined in this investigation it is difficult to say whether the percentage of error is markedly lessened or not. Sound conclusions could only be based on very much larger numbers say 100,000 children. An even more scientifically correct method would be to examine a large number of children (somewhere in the region of 10,000) year by year from the earliest age up to the years when school life ended and thus get reliable figures as to diminution or otherwise of cases of hypermetropic errors. The difficulty of carrying out such a test is enormous and probably accounts for its absence.

The deduction to be drawn from the figures in this investigation is that the number of cases of Hypermetropic defects shows a slight diminution amongst the older children.

In the case of Myopia in the table given above it is seen that there is a quite definite increase in the percentage of cases found amongst the older children. The remarks about percentage error due to paucity of numbers apply with equal force here as in the case of Hypermetropia.

So far, however, as the numbers go, they support the generally accepted view that the cases

of myopia tend to increase amongst children of an older age.

Cohn gives striking figures on this point. He shows that the increase is progressive throughout school life. Risley in Norris & Olivers book agrees with Cohn on the progressive percentage increase of myopic affections from the younger to the older ages of school children. He gives records of 28 cases which were examined by him from year to year and states that his own cases without exception passed from hypermetropia to myopia through the turnstile of astigmatism.

Dr Askins, writing in the Annual Report of the Lancashire School Medical Officer in 1913, gives the results of a large number of retinoscopic examinations of children. He states that 0.5 per cent of children from 4 to 8 years of age exhibit myopic errors.

At age 9.	.88%	showed myopic errors.
At age 10.	1.1 %	showed myopis errors.
At age 11.	.92%	showed myopic errors.
At age 12.	1.9-%	showed myopic errors.

In Askin's reports 334 children were examined. He also states that cases of low degrees of myopia which were absent from children examined below the age of 8 years become more common in the later ages. He comes to the conclusion that the 0.5% found below 8 years are congenital in origin and that the greater percentage in the later years is caused by acquired myopia.

During the course of the present investigation

it was found that the girls showed a greater increase in the percentage of myopia in the later ages than the boys did. From the table it can be deduced that there is an increased percentage of myopic errors found amongst children of later years but it would be difficult to say whether this increase is commensurate with the decreased percentage of Hypermetropia found at the same age period.

In the cases of Mixed Astigmatism it is noticed from the table that there is an increased percentage of cases found amongst the older children. This supports Risley's view previously quoted.

It is conceivable that Mixed Astigmatism may be a definite milestone in the journey from Hypermetropia to Myopia. These figures, however, cannot be used as an instance of "Cause and effect" without possibilities of serious error creeping in. It can only be deduced from them that the percentage of mixed astigmatism increases amongst the older children.

Again returning to the table it is seen that the total percentage of errors of refraction is diminished slightly in the older ages as compared with that of the younger ages.

No further deduction can be drawn from this.

The next factor to be considered is the influence that sex has upon percentages of defective sight, and is now annotated under the heading:-

(c)

THE INFLUENCE OF SEX.

In this part of the investigation the series of figures considered under "The influence of age" is considered along with some others added. In all 560 boys and 580 girls were examined a total of 1,140.

In order to provide greater clearness in the tabulating of the results 3 tables are given, one for each group of defects.

The total percentage of errors of refraction found amongst the boys was 16.0. Amongst the girls it was 21.3 per cent.

The table for the Hypermetropic group of defects is given first and the others immediately afterwards:-

HYPERMETROPIA.

	<u>Total No.</u>	<u>No. Hypermetropic.</u>	<u>Percentage.</u>
Boys.	560	69	12.3
Girls.	580	87	15.0

MYOPIA.

	<u>Total No.</u>	<u>No. Myopic.</u>	<u>Percentage.</u>
Boys.	560	18	3.2
Girls.	580	27	4.6

MIXED ASTIGMATISM.

	<u>Total No.</u>	<u>No. Mixed Astigmatism.</u>	<u>Percentage.</u>
Boys.	560	3	0.5
Girls.	580	10	1.7

It will be seen from the above tables that girls have a larger percentage of defective sight than

boys and that this applies to all the different groups of errors of refraction investigated. The largest relative difference in percentage is found in the case of Mixed Astigmatism.

The Annual Report of the School Medical Officer for Lancashire County for the year 1914 shows that 37,130 boys and 37,314 girls of age 12 had their vision examined during the previous five years. Of the boys 14% has vision less than normal and of the girls 18% has vision less than normal.

In his Annual Report for the year 1910, the School Medical Officer of the same County gives a Table of percentage of errors found in the two sexes. It is quoted below:-

	<u>Boys.</u>	<u>Girls.</u>
Hypermetropic errors	13.9	17.3
Myopic errors	3.4	5.4
Mixed Astigmatism	0.5	2.5

These results correspond closely to the results found in this investigation.

In the compilation of the table given in the section on the influence of age, it was found that the proportion of errors of refraction was greater in girls than in boys at all age periods.

It is difficult to find a satisfactory reason for the greater proportion of errors of refraction found amongst girls, especially when the proportion is found to be greater in all the different groups of defects considered. If it were found in Myopia alone it might be accounted for by the amount of fine sewing performed by girls and also to some extent by the greater amount of reading done by them.

This explanation, however, is without foundation on fact when it is found that Hypermetropic errors and errors due to Mixed Astigmatism are also found in greater proportion in girls.

The theory has been advanced by oculists that the higher percentages of Myopic errors in girls are due to close work, but it has not been advanced that Hypermetropic errors are also increased in girls by the same pursuits. It cannot be true in both cases and is probably true in neither. No satisfactory reason can be given for this phenomenon on the results of this investigation. In the section on Heredity it will be recollected that the maternal influence appeared to be the stronger also in the production of defective sight in the children. There would appear to be some connection between the two phenomena.

The fact then can only be noted that girls exhibit a higher percentage of visual defect than boys and that this is also true for all the different groups of errors of refraction considered.

The next factor which was investigated and which is now dealt with, was:-

(d). THE INFLUENCE OF THE LIGHTING OF SCHOOLS.

It has hitherto been a common and widely accepted view that defective lighting in schools has a deleterious effect on the eyesight of the children. Many oculists have even expressed an opinion that this is an actual cause of Myopia.

Cohn and his followers were of the opinion

that defective lighting was an active agent in the production of Myopia amongst school children.

Risley supports this view. Recently, however, in this country some doubt has been cast on this opinion by competent observers.

A part of this investigation therefore was devoted to obtaining some evidence on this important question. This part was conducted with the same schools and numbers of children as in some of the other sections but special tests were made of the lighting of the schools.

It must be noted, however, that it is difficult now to find schools where the lighting is extremely bad and the schools given as possessing defective lighting are only relatively defective.

In view of the fact that the eyesight of country children is generally considered to be less liable to errors of refraction than that of urban children it was decided that schools situated in both localities should be tested. Moreover that schools badlylighted should be considered and compared with schools more efficiently lit in its own locality and not with schools in a different environment. Thus more strictly comparable results could be attained.

Such schools then were chosen in both rural and urban areas.

It was necessary to test the lighting of the schools in order to get a basis on which to work.

The method of performing the lighting test is now described:-

Method of testing the school lighting.

School work is practically all performed in the hours of daylight so that it was necessary to test this only.

There are many forms of apparatus available for the testing of light values and most of them are extremely cumbersome and difficult to transport. The result aimed at was not so much the estimation of the lighting values of a school as some standard which would act as a basis for purposes of comparison between one school and another.

In order to obtain this standard an ordinary photographic exposure meter was used and was found satisfactory for the purpose.

The principle on which this exposure meter acts is, that a strip of sensitive paper when exposed to light changes from white to black through a variety of shades in accordance with the length of exposure. It possesses a strip of paper of a standard shade with which the shade of the sensitive paper has to be compared. The time taken by the sensitive paper on exposure to light to reach the standard shade is noted.

The exposure meter was used in this way. It was exposed to light in three or more positions in each classroom of the school; the positions being one nearest the main source of light, one furthest away, and one or more at mid distance. The time of exposure was noted in each case which the sensitive paper took to reach the standard shade.

An average time was then struck for the classroom. Readings in the open air were taken before and after testing each classroom in order to obtain controls. The average time of exposure in each room was unified on the open air tests by dividing the average time in seconds of the outside test by the average time in seconds of the classroom tests. This gave a fraction of unity, e.g. .1 or .01.

An average of each school was then obtained by adding the decimal fractions and dividing by the number of classrooms.

As each school was thus unified on the outside readings the results were strictly comparable between school and school.

A certain amount of care had to be exercised in performing these tests in order to avoid direct sunlight as otherwise the results would have been vitiated. The outside readings were taken facing north in order to get more even results and direct sunlight was avoided in the inside tests. As far as possible, bright and cloudless were chosen and all tests were performed at the same season of the year and in the hours just before and just after midday. The inside readings were taken on the school desks at which the children work.

Strictly comparable results were thus obtained.

The same methods of testing the children's eyesight were pursued as previously described. All the children in the school from age six upwards were tested. Infants were not tested as they are so

unreliable to Snellen's test. All children who could not see 6/6 with each eye were subjected to a retinoscopic examination. As an extra precaution those children who presented any appearance of eyestrain were also examined retinoscopically.

Only those children who exhibited errors of refraction of one dioptré or over were noted as presenting evidence of defect. All under one dioptré were enumerated as normal.

The urban and rural schools are considered separately. The results found in the urban schools are now given.

TABLE.

	Light Inten- sity	No. of Chld.	% of Hyper- metro- pia.	% of Myo- pia.	% of Mixed Astig- matism	Total % of Defect
School 1.	0.11	225	14.6	5.3	0.8	20.7
School 2.	0.12	123	20.3	0.4	0	20.7
School 3.	0.03	216	15.2	1.3	1.3	17.8
School 4.	0.05	186	15.0	2.6	1.0	18.6

Before proceeding to analyse the results of this table it must be stated that these urban schools were all situated in one industrial area where the work of the population, the quality of housing, the question of inter-marriage and the general environment were the same for all.

It will be seen from the table that the schools give a good variation in light intensity. Schools 1 and 2 give the best lighting results and Schools 3 and 4 are

much less efficient in this respect. In the actual performance of the lighting test the time of exposure gave even more striking differences between the schools than can be grasped from the decimal figures. In school 2 the average time for the school was 2 minutes 55 seconds whereas in school 3 it was 11 minutes, the outside lighting test being approximately the same in each instance.

Analysis of the table shows that the total percentage of visual defect in the better lighted schools is actually higher than that found in the less efficiently lit. The two better lighted schools give the same percentage of defective sight 20.7. The worst lit school No. 3. gives the lowest percentage of errors of refraction.

If schools 1 and 2 be combined together, their lighting tests being approximately the same and schools 3 and 4 be similarly combined, better figures for purposes of comparison are obtained. The numbers examined in each group of schools then are respectively 348 and 402. The percentages of visual defect are respectively 20.7 and 18.2.

Although these figures show that there is a lower percentage of defective sight in the less efficiently lighted schools than is found in the better lit schools it cannot be deduced from these figures that bad lighting in schools is better for the children's eyesight than good lighting.

It can however be safely concluded that the total percentage of visual defect is no greater

in the less efficiently lighted schools than it is in the better lighted.

Taking the different groups of errors of refractions separately it is seen in the case of Hypermetropic defects that school 11 gives the lowest percentage and school 2 (the best lighted) gives the highest. The less efficiently lit schools occupy an intermediate position. Combining Schools 1 and 2, and 3 and 4 together as before the respective percentages are 16.6 and 15.1. The percentage of Hypermetropic errors is greater in the better lighted schools.

Where, however, the numbers examined are so small it is difficult to dogmatise and it can only be concluded that Hypermetropic errors of refraction are not increased in number in the less efficiently lighted schools and that defective lighting in schools is not an active Agent in the production of Hypermetropic errors.

Myopia

Analysis of tables with respect to myopic conditions shows that the best lighted school shows the smallest percentage of Myopia. In the other well lit school No. 1, the percentage of myopic errors is the highest of all, the two badly lit schools showing quite low percentages. Combining schools 1 and 2 and schools 3 and 4 as before, the respective percentages are 3.7 and 1.9.

These figures show that where the lighting is good the percentage of Myopia is greater than where the lighting is less efficient. This result is in

direct contradiction to the commonly accepted view that defective lighting, or working in a dim light, is productive of myopic conditions. Incidentally it might be mentioned that miners who work in a dim light show no higher proportion of myopic affections than any other working trade.

Cohn is most emphatic in his view that defective lighting in schools causes myopia. He found, however, that in schools where he had improved the hygienic conditions and lighting that the percentage of Myopia did not lessen nor differ to less well lighted schools.

Mixed Astigmatism.

In this defect the percentage of defects found does show an increase in the darker schools over the better lit, namely 1.2 per cent as opposed to 0.5 per cent.

The numbers found suffering from this defect were so small that the percentage error becomes a large one and no scientific conclusion could be based on such small numbers. It can only be pointed out that the percentage of mixed Astigmatism found was greater in the less well lit school and that this is contrary to what was found in the case of Myopic errors.

Rural Schools.

Six schools in all were examined in rural areas. They were widely scattered and had limited attendances of children. In consequence the numbers

examined were small. In all 193 boys and 197 girls were examined, a total of 390.

The same methods of procedure in the lighting tests and eyesight tests were adopted as in the urban schools. Below is given the table of results found:-

	Light Intensity	No. of Chld:	% of Hypermetropia.	% of Myopia.	% of Mixed Astigmatism	Total % of Defect.
School 5.	0.35	71	8.4	7.0	-	15.4
School 6.	0.1	69	11.5	11.5	1.4	23.4
School 7.	0.03	36	5.5	0	2.7	8.2
School 8.	0.1	21	9.5	0	-	9.5
School 9.	0.07	43	16.2	9.3	2.3	27.8
School 10	0.15	150	8.0	4.6	1.3	13.9

The worst lighted school (No. 7.) shows the lowest percentage of defective sight and the best lighted (No.5) shows a higher percentage of defective sight than other less welllighted.

As only small numbers have been examined in each school, the percentage error becomes very high and in consequence much reliance can not be placed upon them. Schools 5, 6, 8, and 10, are all well lighted schools and all show a higher percentage of defective sight than School 7 the worst lighted of all. School 9 which is only comparatively well lighted shows a very high percentage of error but this school will be later on dwelt upon in the section on the Influence of Congnity along with School 6.

Hypermetropia.

The percentages are all rather lower

than in the urban schools and if school 6 and 9 be excluded the percentages are no greater in the less well lighted than in the better lighted schools.

Myopia.

The paucity of numbers examined makes it difficult to form a conclusion but little difference would appear to be present between the well lighted and the less efficiently lit (schools 6 and 9) being excluded for the reasons mentioned above).

Mixed Astigmatism.

No conclusions can be drawn from the figures in these schools where numbers are so small but it would appear that here again there is a slight increase of percentage in the darker schools.

Considering now both urban and rural schools, the following conclusions can be made.

Hypermetropic errors.

That the percentage of errors found is no greater in the badly lighted than the better lighted schools and that defective lighting in schools per se is not a cause of Hypermetropia.

Myopia.

Here again the percentage of errors found is no greater in the badly lighted than in the well lit schools and defective lighting in schools appears to have no effect on the production of Myopic conditions in school children.

Mixed Astigmatism.

The less efficiently lighted schools show a greater percentage than the more efficiently lit.

The next factor to be considered is:-

(e) THE INFLUENCE OF ENVIRONMENT.

It is a generally accepted view that the vision of a population whose pursuits are principally agricultural is on the whole better than that of a population whose pursuits are industrial. This section of the investigation was devoted to obtaining evidence of the truth or otherwise of this dictum when applied to children attending rural and urban schools.

Four urban schools and six rural schools were examined. The same schools and number of children examined are utilized as in the previous section on School Lighting. The methods of testing the vision has been already described. It was found difficult to get rural schools in Mid Lancashire where the work of the population was entirely agricultural, but schools were chosen in districts where the work was mainly agricultural. It has already been noted that the numbers examined in the rural schools was small and in consequence not equal in numbers to those examined in urban schools and therefore not entirely comparable. The results however, are given in percentages in order to overcome the difficulty.

In the urban schools 750 children (367 boys and 383 girls) were tested whereas in the rural schools 390 (193 boys and 197 girls) were examined.

A table is given below of the results found:-

URBAN.

<u>No. exam- ined.</u>	<u>Hyper- metropia</u>	<u>Myopia.</u>	<u>Mixed Astig- matism.</u>
750	15.8	2.8	0.9

RURAL.

390	9.4	6.1	1.5
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Hypermetropic errors show a marked diminution in the rural schools as compared with that found in the urban schools.

Myopic errors. Here the position is reversed and the rural schools show a much higher percentage than the urban.

Mixed Astigmatism. shows an increase in rural schools. The total percentage of visual errors in urban schools is 19.5 whereas in rural schools it is 17 so that on the whole less errors of refraction are found in rural schools.

The percentage of Myopic errors found in rural schools is rather high and is no doubt increased by the paucity of numbers examined but also by the fact that in two of the schools examined the influence of consanguinity is a strong one (this will be considered later). It cannot therefore be concluded from these figures that there is more Myopia to be found in country schools than in urban schools but it would be more correct to conclude

that Myopic defects are as common in rural schools as in urban schools.

The same remarks apply also to Mixed Astigmatism.

In the Annual Report of the Medical Superintendent of Schools, Lancashire (1912), Dr. Jones gives some statistics on this question. He examined 1,955 urban children and 704 rural children and he found the percentage of errors of refraction to be as follows:-

	No. examined	Hypermetropia.	Myopia.	Mixed Astigmatism.
<u>Town.</u>	1,955	12.9	3.7	2.0
<u>Country.</u>	704	13.8	3.0	1.5

His view was that country children showed as many defects as town children and their eyesight was no better.

It is a matter of considerable doubt as to how much effect residence intown or country has on the causation of errors of refraction. A slightly lower percentage of errors is usually found amongst rural children but the difference is very small.

It is difficult to explain why there should be a lower percentage of errors of refraction amongst rural children. Certainly their general physique and health are generally better than that of town children and yet some of the worst cases of Myopia are found amongst agricultural labourers. The hygienic conditions of the home cannot account for it because the worst housing conditions are usually found

in rural areas.

It is in hypermetropic defects that the greatest diminution in percentage is found so it is probable that the real reason for this diminution in rural children is, that they live a more natural life and grow up under better conditions of open air and freedom.

It was noted during the course of this investigation that a larger percentage of defects was found amongst children coming from streets of the slum type, but there are other circumstances that must be considered in connection with such cases over and above the insanitary surroundings. It has generally been found that people who gravitate to such localities are of the "Ne'er do well" class and persons of a low type of mentality. This undoubtedly has an influence on the amount of defective sight because it is known that errors of refraction are very common amongst the mentally unstable. It is common to find high degrees of Myopia amongst children from such localities.

The work of the locality does not appear to have any marked influence on the amount of defective sight found. In the urban schools examined the work of the locality was mainly cotton weaving which demands good vision and concentration of sight. The children of such parents were found to differ but slightly in visual acuity from the children of agricultural parents.

Cohn mentions that the children of composi-

ors show a large percentage of myopic defects, the parents also exhibiting a similar phenomenon. He is of the opinion that family crafts predispose to such errors of refraction. His opinion is not supported by the results obtained in this enquiry.

The conclusion based on this enquiry is, that, except possibly in the case of Hypermetropia where a slight diminution is shown in rural areas, the more artificial life of towns has no more effect on the incidence of Myopic and Mixed Astigmatism errors than the more natural country life.

(f). THE INFLUENCE OF CONSANGUINITY.

It was mentioned in the two previous sections that in two schools where high percentages of errors of refraction were found that intermarriage was a prominent feature in the locality where the schools were situated. These schools will now be considered in more detail. The Schools concerned are 6 and 9 in the tables shown in the section on the "Influence of School Lighting".

It was found when examining these schools for that section of the investigation that abnormal percentages of errors of refraction were found and therefore some enquiries were made into the home conditions and general family histories of the children .

Both these schools are situated in secluded neighbourhoods untouched by railways and off main highways.

In school 6 it was found that every child in the school was related to every other child present and the relationships were both complex and extremely confusing. This was due to the repeated inter-marriages for generations, so that the school could almost be considered to consist of members of one family.

A table is now given of the results found in this school.

SCHOOL 6.

	<u>No. ex- amined</u>	<u>% of Hyper- metropia.</u>	<u>% of Myopia</u>	<u>% of M. Astigsm.</u>
Boys	42	14.2	7.1	0
Girls	<u>27</u>	<u>7.4</u>	<u>18.5</u>	<u>3.7</u>
Total	<u>69</u>	<u>11.5</u>	<u>11.5</u>	<u>1.4</u>

In the area in which School 9 was situated it was found that intermarriages were also common but not to such a marked extent as in School 6 locality. The figures are also given of:-

SCHOOL 9.

	<u>No. ex- amined</u>	<u>% of Hyper- metropia.</u>	<u>% of Myopia</u>	<u>% of M. Astigsm.</u>
Boys	24	16.6	12.5	4.1
Girls	<u>19</u>	<u>15.7</u>	<u>5.2</u>	<u>0</u>
Total	<u>43</u>	<u>16.2</u>	<u>9.3</u>	<u>2.3</u>

Analysing first the Hypermetropic errors, it can be seen that these show a high percentage for rural schools, much higher than the average percentage (7.8) for the other four rural schools tabulated in the section on School Lighting. The numbers

examined of course are small and the percentage error is probably large but the same error applies to the other rural schools examined at the same time and yet the average percentage of Hypermetropic defects is much smaller.

It must therefore be concluded that Inter-marriage is a factor which does have an effect on the etiology of Hypermetropia.

Myopic errors must next be considered and it will be seen from the table that the percentages found are abnormally high in both schools.

Pearson has stated that the average percentage of Myopic errors of refractions found amongst school children is 3. These schools exceed this percentage markedly. The average percentage for the four other rural schools examined was 2.9 of Myopic errors and this percentage is greatly exceeded by the schools 6 and 9. It will also be seen in the tables that both girls and boys exhibit the marked increase and yet both schools are well lighted.

It must be concluded that intermarriage amongst the parents is a very potent factor in the etiology of Myopic errors of refraction.

The number of cases found with Mixed Astigmatism was small and therefore difficult to utilize for the basis of a conclusion but the percentage found is slightly greater than the average.

This section on Consanguinity ought strictly speaking to have been included under the heading Heredity but as different methods were pursued in

dealing with the figures and different children were examined, some lack of continuity in that section would have appeared.

It was considered also that the striking results found justified a separate section.

Whilst not coming strictly within the compass of this enquiry, in that no special investigation was made into the subject, but in view of the authorities quoted from other countries, it was felt that the question of Etiology of defective vision could not be completed without a few observations on:-

(g) THE INFLUENCE OF RACE.

In this country Hypermetropic errors usually predominate amongst school children and myopic errors show a much less percentage. In Germany the percentage of myopic errors is very much higher than in England. The Americans also show a large percentage of Myopic errors.

Native races, such as the American Indians have a large percentage of Hypermetropic defects and a low percentage of Myopic ones.

In the Jews, the percentage of myopic defects quite overshadows the hypermetropic ones. The author of this investigation found in Manchester out of a very large number of Jews examined with defective sight only one hypermetropic case, all the rest were myopic. These were hospital patients, not all school children.

The racial influence is a strong one in the etiology defect due to errors of refraction.

A RESUME OF THE RESULTS FOUND AND THE CONCLUSIONS
BASED ON THEM.

The various groups of defects are considered separately:-

HYPERMETROPIC DEFECTS.

- (a). Heredity. A history of parental defective vision was found in 28.3% of cases. Mothers were affected more often in the proportion of 17.7% to 6.7% of the Fathers. The Familial Predisposition was found in 58% of cases.
- (b). Age. The percentage was found to have decreased from 14.9 in the younger children to 11.7 in the older.
- (c). Sex. 15% found in girls and 12.3% in boys.
- (d). School Lighting. Rather more found in better lighted schools than in the less effectiently lit in porportion of 16.5% to 15.1 % in urban schools and a similar result found in rural schools with less percentages.
- (e). Environ-ment. Less found in rural schools than in urban schools but the difference in the percentage is probably small.
- (f). Consang-unity. Increased percentage found where the parents are intermarried and closely related.
- (g). Racial. More Hypermetropia found in English people than Myopia.

The conclusions based on these results have to a large extent been embodied in the report but are now recapitulated.

1. That Heredity plays a very large part in the production of Hypermetropic defects and a history of parental defective sight will be found in about 40 per cent of all cases of Hypermetropia. The Maternal side of the family has a greater influence in passing on defective sight. All children in the family are not affected where one or other parent is defective in sight. In about 60 per cent of cases of Hypermetropia, other members of the family exhibit defective sight.
2. The number of cases of Hypermetropia was found to be decreased amongst the older children but whether this was due to a certain number of Hypermetropis becoming Myopic or to a certain number becoming Emmetropic, it was not possible to decide. The latter is probably true, for Hypermetropic defects are known to show a tendency to spontaneous cure.
3. Hypermetropia is less common in boys than in girls. No satisfactory conclusion can be based on this phenomenon. There may be some connection between this fact and the fact that the maternal influence is the greater in Heredity. The more open air life and consequent improvement of physical condition of boys may have some bearing on this fact.
4. The number of cases of errors of refraction due to Hypermetropic defects was found not to be influenced at all by the lighting of schools. Defective lighting in schools is certainly not a causal agent of Hypermetropia.
5. Hypermetropia is slightly less common in rural areas than in urban but the difference in percentage of cases is very small. Residence in town or country has no influence in the causation of Hypermetropic conditions, and but slight effect in their persistence.
6. Close relationship between the parents is a potent factor in the causation of Hypermetropia and the percentage of cases found in such families is very much above the average.
7. Hypermetropia is the commonest error of refraction found amongst English school children.

In conclusion it may be said whilst Hypermetropia may be the normal state of a baby's eyes at

birth, the persistence of this state or its allied Astigmatisms is determined largely by the question of Heredity. It is logical that the size of a child's eye should be determined by the size of the parents eyes just as the child's height or length of limbs or colour is so determined.

Mendel's Law is no doubt also applicable here.

MYOPIC DEFECTS.

- (a). Heredity. Evidence of parental defective vision was found in 36.9 per cent of cases. The maternal defect was found to be 22.4 per cent as compared with 9.4 percent in the father. Other children in the family were found to have defective vision in 19.8 per cent of cases where no parental defect apparently was present. The familial predisposition was found in 56.7 per cent of the cases.
- (b) Age. The percentage of cases affected was found to be greater amongst older children, 4.9 per cent as compared with 2.7 per cent in the younger.
- (c). Sex. More Myopic defects were found in girls than in boys; 4.6 per cent as compared with 3.2 per cent.
- (d). School Lighting. 3.7 per cent found Myopic in well lighted schools and 1.9 per cent in less efficiently lit schools in urban areas. An increased percentage also found in well lighted schools in rural areas.
- (e). Environment. Myopia found slightly more common in rural areas than in urban areas. More Myopia found amongst children from slum streets than the average.
- (f). Consanguinity. Close relationship between the parents produces a very much higher percentage

the
of Myopic errors amongst/children
than the average. 10 per cent was
found as compared with 3 per cent
the average. Both girls and boys
showed an increased percentage.

- (g). Racial. The percentage of Myopic defects is lower in English schools than in Germany or the United States. Jews show a high percentage of Myopic errors.

The conclusions based on these results have been given under the heading of each factor considered but are now repeated.

1. That Heredity is probably the most important factor in the etiology of Myopic defects. Parental defective sight has been found in at least 36 per cent of the cases. The maternal influence in heredity is greater than the paternal one. Generally more than one case of Myopia is found in a family. All the members of a family are not as a rule affected and those who have defective sight are not all affected by Myopic conditions. Mixed Astigmatism is not uncommonly found in brothers or sisters of those affected by Myopia but other defects are also found. In about 60 per cent of the cases, other members of the family are affected by errors of refraction.
2. More children affected by Myopic errors of refraction are found in the older ages, but this increase is not commensurate with the decrease in Hypermetropic defects. It must not be concluded that this increase in number of children affected by Myopic defects is due to what is commonly called Acquired Myopia but rather to the fact that Myopia is probably always due to an inherited or inherent weakness of the coats of the eyeball and that these coats yield somewhat and thus produce Myopia during and owing to the demands which the growth of the child puts upon its strength. This theory of the increased percentage of Myopia found in the older ages was arrived at because it was found that the factors such as school lighting, which are commonly supposed to cause Myopia, were found to have no effect on its etiology.
3. More Myopia defects are found in girls than in boys and no satisfactory explanation of this fact

can be found. It is certainly not due to the sewing done by the girls because other errors of refraction which cannot be effected by near work are also found to have a higher incidence in girls than in boys.

4. Defective lighting in schools has no effect on the incidence of Myopic errors. As many defects are found in the children attending well lighted schools as in those attending less efficiently lit schools, and this applies to both rural and urban schools. Defective lighting in schools is not a casual agent in the production of Myopia.
5. Myopia is just as frequently found in rural areas as in urban areas and town life is not an influence in the production of Myopia. More Myopia is found amongst the children coming from the poorer class streets but this is probably more due to the low mental development of their parents than to the insanitary surroundings.
6. Close relationship between parents was found to be a potent factor in the etiology of Myopic defects. The children of such marriages show an incidence of Myopia three times greater than the average.
7. Myopia is nothing like so common amongst English school children as it is amongst the Germans, Americans or Jews.

In conclusion, heredity is probably the most potent factor in the etiology of Myopic defects. The so called acquired Myopia is not acquired in the true sense, that disease or defect has been produced in a previously healthy organ by purely extraneous circumstances or influences, but is rather to be regarded as a development or manifestation of defect in an eyeball which has an inherent weakness in the coats. This inherent weakness is hereditary and the Myopia would ultimately develop in the eye in whatever situation the child be placed.

A Myopic condition of the eye must be regarded

as a diseased condition. It is closely related to the Mental Neuroses and other diseases of the higher Mental Centres.

MIXED ASTIGMATISM.

- (a). Heredity. 38.2 per cent of the parents of children affected by Mixed Astigmatism showed evidence of visual defect. The maternal influence was greater than the paternal .49.8 per cent of the cases affected with this defect showed visual defect amongst other members of the family. Brothers or sisters examined of the cases showed Myopic errors frequently but Hypermetropic errors were also found.
- (b). Age. 1.2 per cent found in the older ages as compared with 0.7 per cent in the younger children.
- (c). Sex. More cases found amongst girls than boys in the proportion of 1.7 per cent 0.5 per cent.
- (d). Lighting. More cases found in the less efficiently lighted schools than in the well lighted schools. This applied to both rural and urban schools examined.
- (e). Environment. A larger percentage of cases found in the country schools than in the urban schools.
- (f). Consanguinity. The percentage of errors found is markedly increased over the average percentage where the parents of the children were found to be closely related before marriage.

CONCLUSIONS.

1. That Heredity plays a large part in the production of errors of refraction due to Mixed

Astigmatism and that the Maternal influence is the more potent one in passing on the defect to the next generation. The Familial predisposition to this defect or other defects of sight was found to be about fifty per cent.

2. More cases of this defect are found in older children and more frequently in girls than in boys and is thus closely related to Myopic conditions.
3. More cases are found in schools where lighting is defective.
4. More cases are found in country schools than in rural schools.
5. Close relationship between the parents before marriage is a potent factor in producing this defect.

All these conclusions in this defect must be regarded as relatively accurate only, as due to the paucity of numbers found, the percentage error was a large one and are intended rather to be conclusions based on the results found than scientific conclusions based on larger numbers.

Gerald Gage Wray.